

# (12) UK Patent Application (19) GB (11) 2 327 523 (13) A

(43) Date of A Publication 27.01.1999

(21) Application No 9715172.4

(22) Date of Filing 18.07.1997

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(51) INT CL<sup>6</sup>  
G09G 3/30, H02M 7/44, H05B 33/08

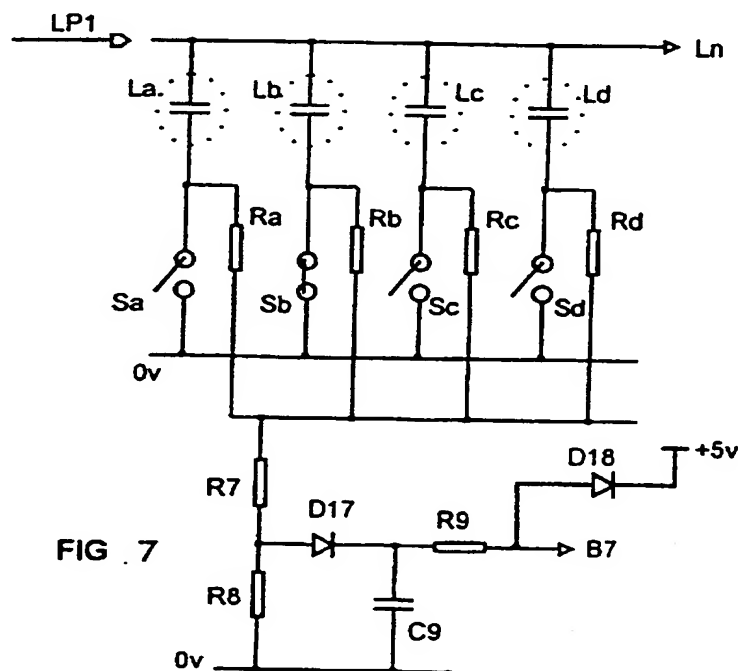
(52) UK CL (Edition Q )  
G3U UAE9 U210 U212

(56) Documents Cited  
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(58) Field of Search  
UK CL (Edition P ) G3U UAE9 UAX , G5C CHB  
INT CL<sup>6</sup> G05F 1/12 , G09G 3/12 3/30 , H02M 7/44 ,  
H05B 33/08  
Online: EDOC, JAPIO, WPI

(54) Abstract Title  
**Electroluminescent lamp driver**

(57) A display panel has a plurality of electroluminescent lamps La...Ld each of which can be selected by a respective triac switch Sa...Sd. The AC voltage LP1 supplied to the lamps by an inverter is detected by a resistor network Ra...Rd, R7, R8, rectified and provided as a control voltage to a microprocessor which controls the inverter so as to keep its output voltage constant. The shunt-connected resistors Ra...Rd change the magnitude of the feedback voltage dependent on the number of lamps selected. The microprocessor also adjusts the supply voltage so as to compensate for the age of the lamps and keep the brightness constant.



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FIG 1. BASIC BLOCK DIAGRAM

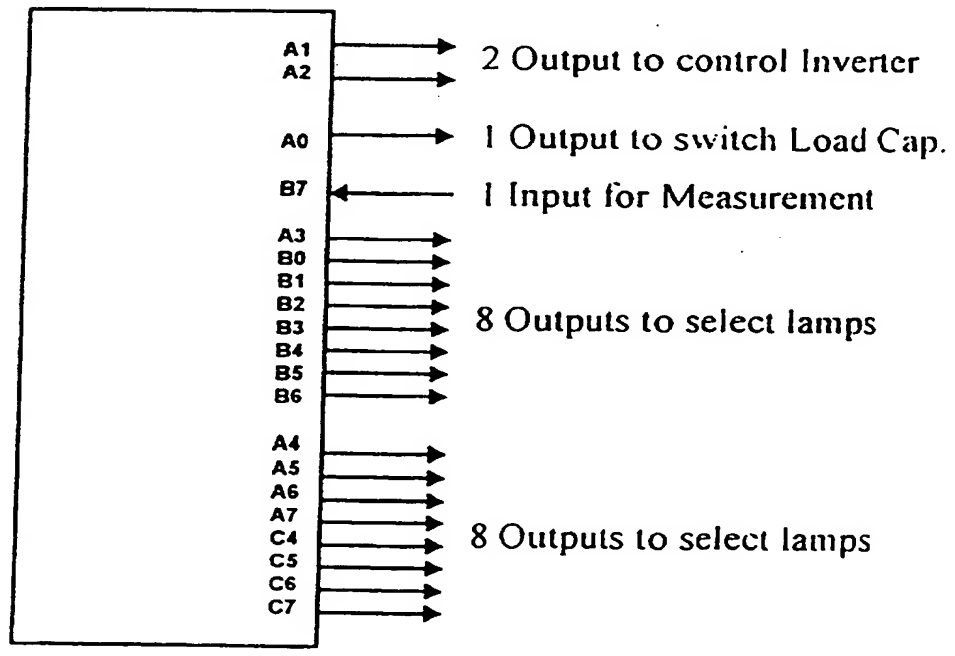
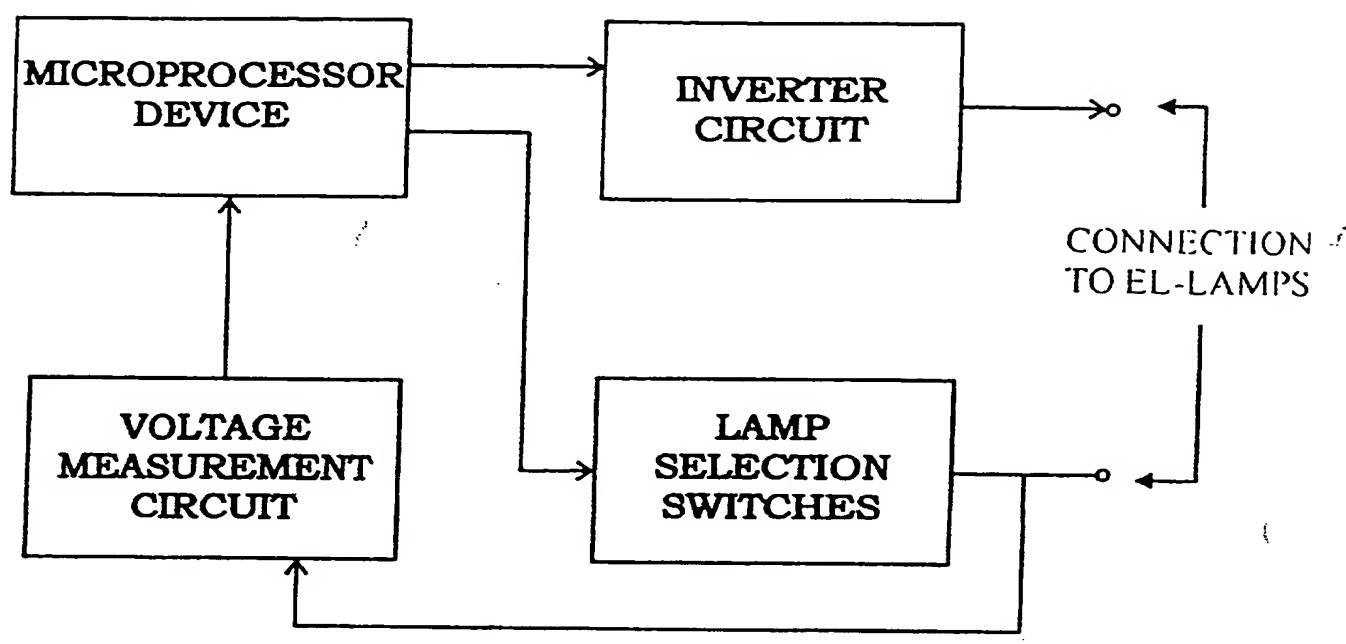


FIG 2. MICRO-CONTROLLER ( 20-PORTS )

FIG. 3

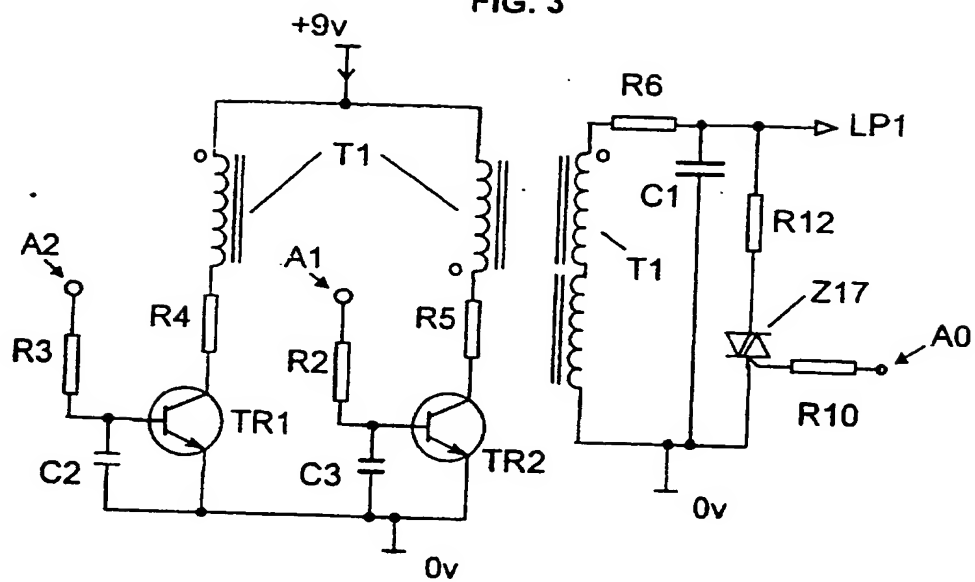


FIG 4

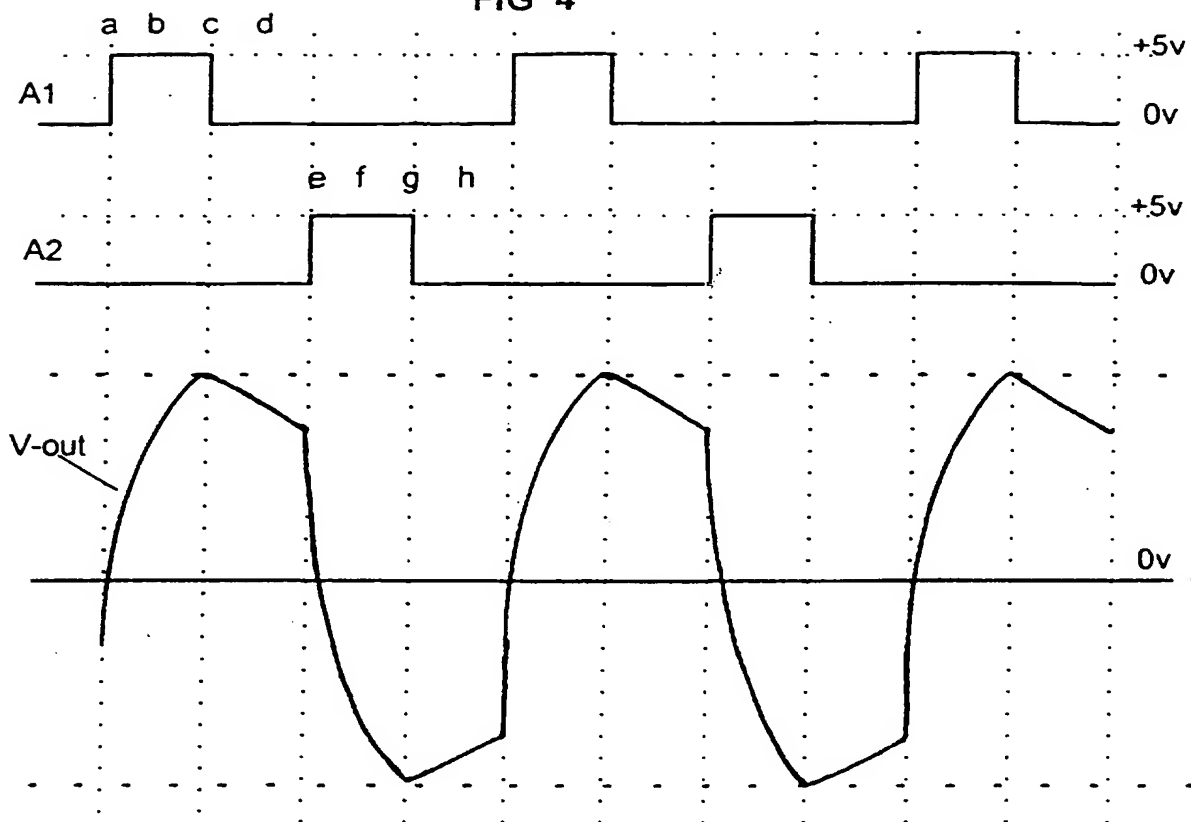


FIG. 5

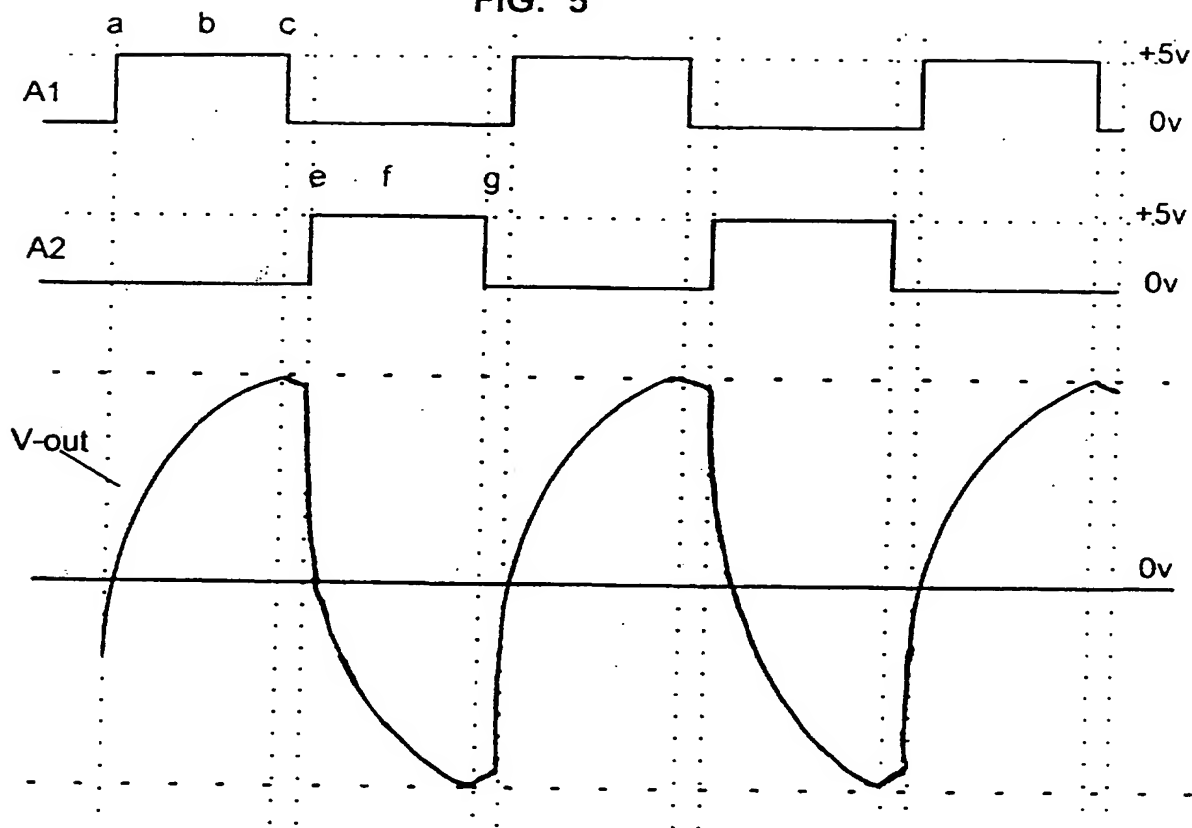
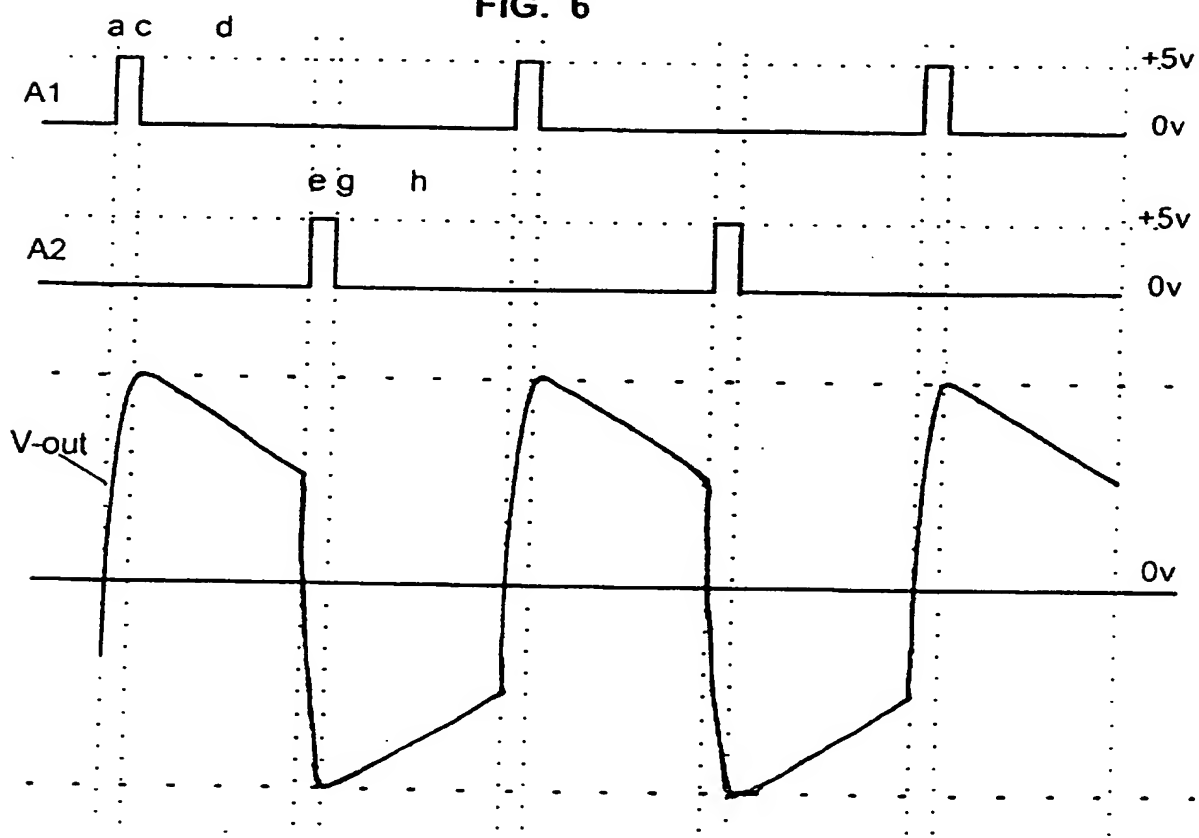


FIG. 6



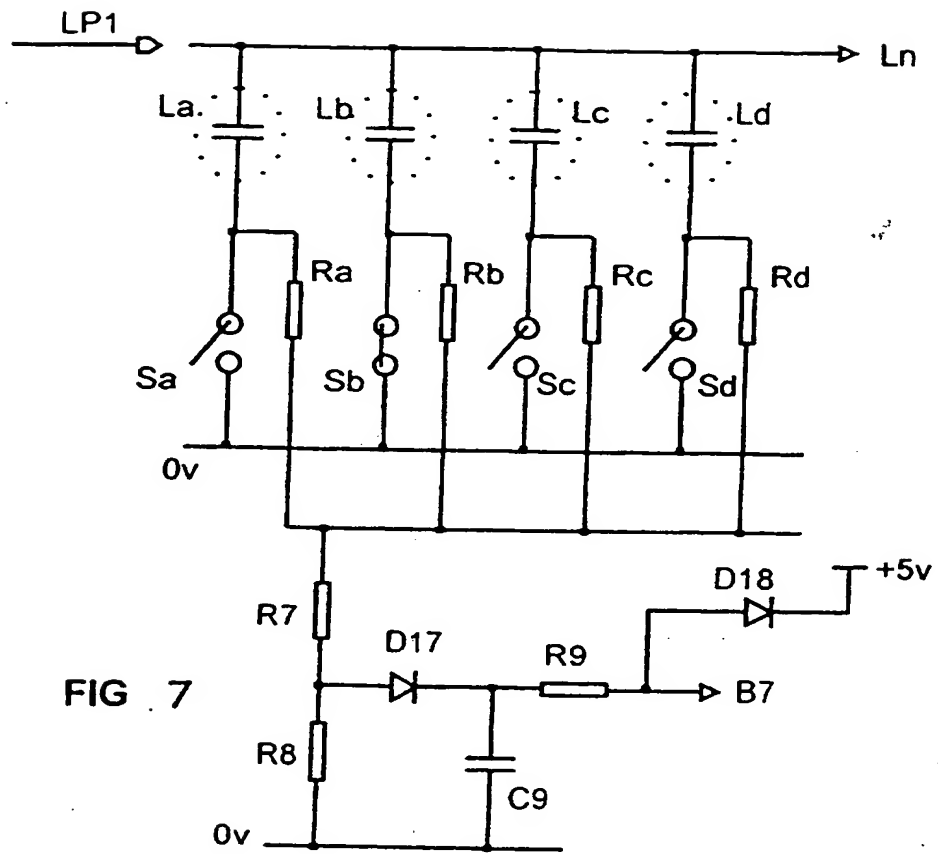


FIG 7

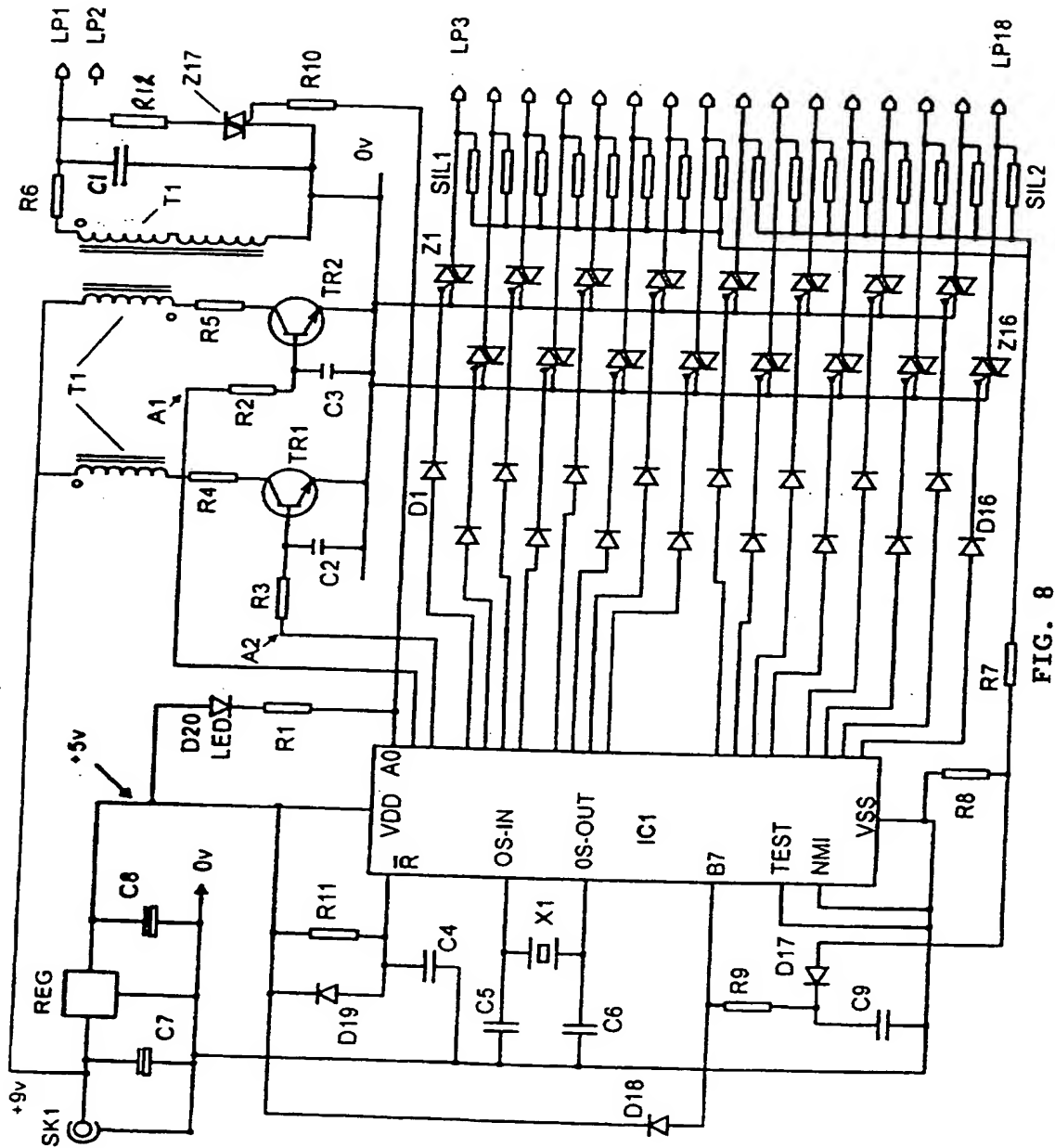


FIG. 8

**2327523****ELECTROLUMINESCENT LAMP DRIVER**

The present invention relates to an electroluminescent lamp driver for providing power to a variety of different electroluminescent display panels without any change to the electric circuits employed.

An electroluminescent display panel is made up of a number of lamp segments each of which is either a single electroluminescent (EL) lamp or a group of lamps with a common electrical connection. All the parameters for driving the electroluminescent lamps and for selecting which lamp or lamps are being lit, is under software control. Therefore any size and number of electroluminescent lamps can be lit, up to the maximum output capacity of the driver.

With this invention, the same basic hardware (electronic circuits) can be used to drive a display panel that is designed to each customer's requirement. As the electroluminescent lamps have a limited life they can be replaced with a new display panel of the same type or a completely new layout. In the latter case, the software controlling the microprocessor must be changed to suit the new display. Software has been designed to allow these changes to be made easily by using a separate table to hold all the main parameters. This table can be inside the microprocessor or on a separate device, i.e. EEPROM, flash memory or a Smartcard. Measurements are taken to confirm that the lamps are being driven at the correct level dependent on the ageing characteristics of the lamp.

According to the present invention there is provided an electroluminescent (EL) lamp driver for driving an EL display panel comprising a plurality of lamp segments, said driver comprising an inverter circuit for supplying to said display panel a high AC driving voltage, microprocessor means for controlling the characteristics of said AC voltage inverter, switch means controlled by said microprocessor for selectively switching individual lamp segments, a measurement circuit for deriving a feedback signal indicative of the AC driving voltage and means



for applying said feedback signal to the microprocessor as a control signal.

In an embodiment, said measurement circuit includes means for altering the feedback voltage in accordance with the number of lamp segments which are selected by said switch means at any one time. In the preferred embodiment, said altering means comprises a plurality of resistors, each connected at one end to a respective lamp segment and connected such that, when a particular lamp is selected by said switch means, its resistor is connected in shunt with the measurement circuit and when a lamp is not selected by said switch means, its resistor is connected in series with the measurement circuit. Thus, it will be seen that the effect of switching in more lamp segments is to reduce the magnitude of the feedback voltage because of the shunting effect of the resistor or resistors.

In a further embodiment the switch means comprises lamp selection switches with there being one switch for each EL, each switch being connected to an EL lamp at one end and having a control electrode connected to a respective output port of the microprocessor, such that said switches are switched on by the supply of a small current directly from the output ports of the microprocessor.

In another embodiment said inverter circuit allows current to pass through the primary windings of a transformer, whereby inputs to the inverter circuit are connected to and controlled by a microprocessor such that only one output is active at a time so that each half of the transformer in the inverter circuit is driven alternately.

In a further preferred embodiment the microprocessor runs a program enabling access to all parameters relating to particular display panels, such that the on/off ratio and drive levels of the input voltage to the inverter circuit may be varied by the said microprocessor according to the particular display panel selected. Preferably the parameters relating to particular display panels are stored in a table in the memory of the

microprocessor. Alternately the table is stored on a separate device such as EEPROM, flash memory or a Smartcard.

A specific embodiment of the invention will now be described by way of example with reference to the accompanying drawing in which:-

Figure 1 is a block diagram of an embodiment of a lamp driver according to the present invention,

Figure 2 shows the Input/Output ports of the microprocessor device forming part of the lamp driver of Figure 1,

Figure 3 is an electrical diagram of the Inverter Circuit forming part of the lamp driver of Figure 1,

Figure 4 shows typical input and output wave forms of the inverter circuit of Figure 3,

Figure 5 shows the input and output wave forms of the inverter circuit for maximum loads,

Figure 6 shows the inputs and output wave forms of the inverter circuit for minimum loads,

Figure 7 shows the operation of the voltage measurement circuit forming part of the lamp driver of Figure 1,

Figure 8 is an electrical diagram of an embodiment of a lamp driver according to the invention.

The main elements of the lamp driver are shown in Figure 1 and are a microprocessor device, an inverter circuit, lamp selection switches and a lamp voltage measurement circuit.

The microprocessor device is from the SGS-Thomson ST6 family. This consists of a range of devices in two basic sizes, 20 pin and 28 pin. The printed circuit board of the invention has been designed to accept both sizes. The device chosen is a micro-controller as it has all the input/output ports, program memory (ROM), variable memory (RAM) all on a single integrated circuit (IC1). The type of manufacturer is not a major consideration as long as all the required functions are available.

These functions could be on one single IC or made up of using separate ICs.

The Input/Output ports of the 28 pin microprocessor device are shown in Figure 2. There are 2 output ports A1 and A2 which drive the inverter circuit, 1 output port A0 controls the EL lamp discharge path via triac Z17 of the inverter circuit and which also controls the indicator LED (D20 in Fig. 8).

Output ports A3..A6, B0, B6, C4, C7 are used to select each lamp using a triac switch. In the present embodiment either 8 or 16 EL lamps can be used. However, this number can easily be increased by using data switches and decoding the output lines from the micro-controller. There is 1 input port B7 connected to an analogue to digital converter (A to D) converter for voltage measurement.

Positive going (high) pulses on each output pin A1 and A2 in turn, turn on drive transistors TR1 and TR2 forming part of the inverter circuit, shown in Figure 3, which transistors pass current through the respective primary windings of a step-up transformer T1. Only one output is active at a time so that each half of the transformer in the inverter circuit is driven alternately. The frequency of these pulses determine the output frequency of the inverter circuit. The on/off ratio of the pulses determines the primary drive current which sets the output voltage. Therefore the optimum drive conditions can be set up by the measurement circuit and software within the micro-controller.

If the ageing characteristics of the lamp are known (by means of prior test results) then the high/low ratio of the pulse signals on plus A1 and A2 can be changed to compensate for the fall in light output. This will result in a constant light level for the life of the lamp.

The output port A0 of the inverter circuit controls a triac switch Z17 (see Figure 8) via a resistor R10 which allows the resistor R12 to be connected or disconnected to 0 volts. This is done for short periods while A1 and A2 are both low and will rapidly discharge (the load capacitor) C1

and the EL-lamp between positive and negative half cycles. This output also controls the LED D20 via R1. This is used to indicate the working condition of the unit.

The printed circuit board has been laid out to take two different size micro-controllers. The smaller 20 pin device has the first 8 outputs available, whereas the 28 pin device has all 16 outputs. These are used to select EL lamps using the triac switches Z1 to Z16 via diodes D1 to D16.

The SGS Thomson micro-controller has several input lines that can be internally connected to an Analogue to Digital (A to D) converter. One such input B7 is used to measure the voltage level applied to any of the electroluminescent lamp segments. This measurement can be used to control the drive conditions of each lamp so that the voltage does not exceed the maximum rated level for the lamp. It can also be used to confirm that the correct display panel has been connected and each lamp is working correctly.

The high gain transistors TR1 and TR2 act like switches which are controlled by the microprocessor output terminals A1 and A2. The transformer T1 has a high secondary to primary turns ratio to produce a high level ac voltage up to a maximum of 600 volts pk-pk. Transformer T1 is custom designed to produce a smooth output wave form from a fast switching input voltage. The primary is centre tapped to allow equal current flow in both directions which alternates the primary voltage. The centre tap is connected to +9 volts which is supplied via SK1. Only one transistor TR1 or TR2 will be switched on at any time connecting the outside primary terminals of T1 to 0 volts via the resistors R4 and R5. The components R3, C2 and R2, C4 reduce the switch on speed of the transistors.

Most electroluminescent lamps use an inverter circuit which is based on a high voltage oscillator turned to suit the frequency and voltage required for a particular EL lamps size. To drive a different lamp component values must be changed to suit the new lamp.

In the inverter circuit shown in Fig. 3 a dc voltage is switched at a frequency of between 1500 Hz and 1900 Hz across the primary windings of the transformer T1. As this is a step-up transformer a high voltage is produced across the secondary winding at the same frequency. Unlike a switch mode power supply, this secondary voltage is not rectified but is applied as an ac voltage to directly drive the electroluminescent lamps. The frequency and output voltage are under the control of the microprocessor with feedback provided via the measurement circuit.

The brightness of the lamp is determined by the AC voltage and the frequency. In this embodiment the frequency is chosen to suit the type of phosphor used by the manufacturer of EL lamps. Light is produced during the transition from positive to negative or negative to positive potential across the terminals of the lamp. Therefore the shape of the wave form is not of particular importance. However, the transitions must be smooth to avoid damaging the lamps. This is achieved by the choice of transformer T1 and the addition of a load capacitor C1. The resistor R6 is intended to limit the output current under fault conditions.

Figure 4 shows the relationship between the switching wave forms A1 and A2 and the output wave form V-out of the secondary of T1 measured at connector pin LP1. When A1 is high the transistor TR1 is switched on and when A2 is high the transistor TR2 is switched on. One cycle of the output wave form is produced by the following sequence:-

- a) A1 goes high. TR1 turns on allowing current to flow in the primary of T1. V-out starts to rise.
- b) A1 stays high. The output voltage V-out rises positively at a rate dependent on the load capacitor and the size of the electroluminescent lamp connected to the output.
- c) A1 goes low, TR1 turns off. The output voltage can no longer rise. The voltage that has been reached is determined by the length of time that A1 was high.

- d) Both transistor switches, TR1 and TR2 are off and no current is flowing through the primary of T1. The output voltage decays slowly due to the capacitor effects of C1 and the electroluminescent lamp.
- e) A2 goes high, TR2 is switched on. Current flows through the second half of the primary winding of T1. This reverses the voltage in the primary and causes the secondary voltage to increase in the negative direction.
- f) A2 stays high. The output voltage  $v_{out}$  increases in the negative direction at a rate dependent on the load capacitor C1 and the size of the electroluminescent lamp connected to the output.
- g) A2 goes low, TR2 is turned off. The output voltage has reached its maximum negative value.
- h) Both transistor switches TR1 and TR2 are off in the same condition as (d).

This process continues and creates an ac output wave form which is not a sine wave or square wave. The shape is dependent on the size of the electroluminescent lamp that is connected to the output.

Figure 5 shows the microprocessor outputs A1 and A2 that would be needed to generate an out wave form to drive a large electroluminescent lamp or a number of smaller lamps which are ON at the same time. As the electroluminescent lamps represent a capacitive load the rise time is much slower. The periods (a) and (f) are set to the maximum time to achieve the same output voltage swing  $V_{out}$ . The transistor switches TR1 and TR2 will remain on for longer. There is only a very short time when both transistors are off.

Figure 6 shows the same output voltage reached by  $V_{out}$  for the condition when a small electroluminescent lamp is connected to output LP1. The peak-to-peak voltage remains the same so that a small lamp has the same brightness as a large lamp. As the small lamp represents a much smaller capacitive load, the rise time of the output voltage  $V_{out}$  is faster. Therefore the transistor switch TR1 and TR2 are only on for a short time

between (a) and (b) and (e) and (f) as A1 and A2 are high for a short period only.

In this way different EL lamps and combinations of lamps can be driven from the same Inverter circuit by controlling the on/off ratio of A1 and A2. As the voltage and frequency are kept the same for large and small lamps they will have the same brightness and age at the same rate.

The efficiency of this inverter circuit is improved by discharging the output voltage V-out just before the transition from the maximum positive voltage to the negative half cycle and from the maximum negative voltage to the positive half cycle. The voltage is quickly discharged through the resistor R12 when the triac switch Z17 is turned on by the output port A0. The transformer T1 can achieve the required output voltage with less power in the primary windings. This is another unique technical feature of this invention.

Referring now to the circuit diagram of Figure 8. The triacs Z1 to Z16 are commonly used for switching high voltage wave forms. In this embodiment devices rated at 600v ac are used. A lower power device has been chosen which can be driven directly from an output port of the micro-controller. The triacs are switched on by supplying a small current directly from the output ports of the micro-controller into the gate of the triac. The connection to each triac is via the diodes D1 to D16. A series diode is used to avoid the risk of current flowing in the wrong direction and damaging the micro-controller. During the times when the triacs are being switched on or off the Inverter circuit is not operating so that the voltages are at a lower level.

For this embodiment each electroluminescent lamp in the display panels must be electrically connected to an in-line socket of 0.1 inch pitch. The electroluminescent lamp panels are manufactured so that all lamps have one of their terminals connected to a common point. This is always connected to the output of the inverter circuit via LP1. In this way the high ac voltage is applied to one terminal of every lamp. The second

terminal of each lamp is connected to a respective triac switch Z1 to Z16 via the plug pins LP3 to LP 18. When a triac is switched on this terminal is connected to 0 volts and a small current flows through the lamp making it light.

Figure 7 illustrates the operation of the EL lamp selection. LP1 is the output from the inverter circuit. For the sake of clarity, just four triacs are shown, represented as switches Sa, Sb, Sc and Sd connected to EL lamps represented by La, Lb, Lc and Ld. In a typical application there would be one triac for each electroluminescent lamp (normally 8 or 16). They will operate like a switch because current can flow in either direction. The switch Sb is shown in the ON position and the EL lamp Lb will be lit when the inverter produces an AC voltage at LP1.

As each lamp on an EL lamp panel is connected to a triac switch, any lamp or combination of lamps can be switched on or off. The time they are on is determined by the software and the display table. This also controls the output level (brightness) of each lamp. If more than one lamp is switched on, this invention will compensate for the additional load by increasing the inverter circuit drive conditions to keep the output ac voltage constant.

In some applications where the electroluminescent lamp panel is only required for a short time the measurement circuit is only used to confirm that the correct lamp has been connected and the voltages are within the normal operating limits.

If a lamp is required to have a constant brightness level over a longer time period then action must be taken to compensate for ageing. All electroluminescent lamps will age at a predictable rate. For any given drive voltage and frequency the brightness will reduce with time. This effect can be reduced by increasing the drive voltage to compensate for the reduction in brightness over time. Therefore it is necessary to start from an initial voltage which is well below the maximum operating



voltage of the lamp. As the voltage is increased the rate that the lamp ages also increases.

In this embodiment internal EEPROM memory is used within the micro-controller to keep a record of the run time of an electroluminescent lamp panel. A specially written program is used for controlling the micro-controller so that the voltage applied to the lamp is measured and adjusted to be at the correct level for the age of the lamp. In this way the lamp is kept at a constant brightness level.

Referring to the circuit diagram of Figure 8 the measurement circuit consists of 2 single-in-line resistor packs SIL1 and SIL2, resistors R7, R8 and R9, capacitor C9 and diodes D17 and D18. The output from the circuit is applied to pin B7 of the micro-controller which has been configured as an A-to-D converter.

The operation of the measurement circuit is illustrated in Figure 7. The electroluminescent lamps can be considered as acting like capacitors. Each lamp is connected to a high value resistor Ra, Rb, Rc and Rd which are part of the single-in-line resistor packs SIL1 or SIL2. R7 is also a high value resistor. When the triac switches are off, the high AC voltage appears on both sides of the electroluminescent "capacitors". In this example, when the switch Sb is closed the electroluminescent lamp Lb becomes a capacitive load as one terminal of Lb is now connected to 0v. The capacitive load seen by the inverter which depends on the size of the lamp Lb. The ac voltage on the switch side of all the non-selected lamps La, Lc and Ld is the same as the AC voltage driving the selected lamp Lb. This voltage is divided down by a resistor chain (Ra, Rc, Rd in parallel plus R7 and R8) to a low AC voltage across the resistor R8. This is rectified by diode D17, smoothed by capacitor C9 and measured as a DC voltage at B7. This DC voltage is in direct proportion to the original high AC. The DC voltage is connected to the micro-controller input pin B7 to be read by the internal A to D converter. B7 has a high impedance

compared to R9. D18 and R9 are for the protection of the micro-controller against voltages exceeding +5 volts.

Referring again to Figure 8, the micro-controller IC1 requires a +5 volt DC supply to pin 1 shown as VDD. This is provided by a 3 pin regulator REG which converts the +9 volt input from socket SK1 to a +5 volt output. The 3<sup>rd</sup> terminal of REG is connected to Ov from SK1. This is also connected to the VSS pin on IC1. C7 and C8 are electrolytic capacitors.

Resistor R11, capacitor C4 and diode D19 form a reset circuit. The presently described embodiment does not have a ON switch so IC1 has a delayed start up to allow the voltages to stabilise after a connection is made to SK1. Capacitors C5, C6 and crystal X1 form an oscillator circuit with IC1.

The software has been written to be as flexible as possible and the unit has not been designed for any particular design of display panel. The program can switch on any EL lamp or combination of lamps and drive the inverter circuit to provide the required output level for the desired on-time. The ability to set different output drive levels from the invert circuit is unique to this invention. All the parameters relating to a particular display panel are held in a separate table (or tables) which are accessed by the main program. The tables can be in the ROM memory of a OTP (One Time Programmable) device together with the main program. The software has been written so that even this type of device can be re-programmed and a new table added (up to the memory limit of the device). The table could be in EEPROM (Electrically Erasable Read-Only Memory) or FLASH memory, which can be inside or outside the microprocessor IC. Alternatively the table could be on a plug in device such as a Smart card to allow for quick and easy changes of the display panels.

CLAIMS

1. An electroluminescent (EL) lamp driver for driving an EL display panel comprising a plurality of lamp segments, said driver comprising an inverter circuit for supplying to said display panel a high AC driving voltage, microprocessor means for controlling the characteristics of said AC voltage inverter, switch means controlled by said microprocessor for selectively switching individual lamp segments, a measurement circuit for deriving a feedback signal indicative of the AC driving voltage and means for applying said feedback signal to the microprocessor as a control signal.
2. An electroluminescent lamp driver as claimed in claim 1 wherein, the measurement circuit includes means for altering the feedback voltage in accordance with the number of lamp segments which are selected by said switch means at any one time.
3. An electroluminescent lamp driver as claimed in claim 2 wherein, the altering means comprises a plurality of resistors, each connected at one end to a respective lamp segment and connected such that, when a particular lamp is selected by said switch means, its resistor is connected in shunt with the measurement circuit and when a lamp is not selected by said switch means, its resistor is connected in series with the measurement circuit.
4. An electroluminescent lamp driver as claimed in claim 3 wherein, switching in more lamp segments reduces the magnitude of the feedback voltage due to the shunting effect of the resistor or resistors.
5. An electroluminescent lamp driver as claimed in any one of claims 1 to 4 wherein, the switch means comprises lamp selection

switches with there being one switch for each EL lamp, each switch being connected to an EL lamp at one end and having a control electrode connected to a respective output port of the microprocessor, such that said switches are switched on by the supply of a small current directly from the output ports of the microprocessor.

6. An electroluminescent lamp driver as claimed in any one of claims 1 to 5 wherein, the inverter circuit allows current to pass through the primary windings of a transformer, whereby inputs to the inverter circuit are connected to and controlled by a microprocessor such that only one output is active at a time so that each half of the transformer in the inverter circuit is driven alternately.

7. An electroluminescent lamp driver as claimed in any one of claims 1 to 6 wherein, the microprocessor runs a program enabling access to all parameters relating to particular display panels, such that the on/off ratio and drive levels of the input voltage to the inverter circuit may be varied by the said microprocessor according to the particular display panel selected.

8. An electroluminescent lamp driver as claimed in claim 7 wherein, the parameters relating to particular display panels are stored in a table in the memory of the microprocessor.

9. An electroluminescent lamp driver as claimed in claim 7 wherein, the parameters relating to particular display panels are stored in a table which is stored on a separate device such as EEPROM, flash memory or a smartcard.



Application No: GB 9715172.4  
Claims searched: 1-9

Examiner: David Brunt  
Date of search: 6 November 1998

**Patents Act 1977**  
**Search Report under Section 17**

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): G3U (UAE9, UAX), G5C (CHB)

Int Cl (Ed.6): G05F (1/12), G09G (3/12, 3/30), H02M (7/44), H05B (33/08)

Other: Online: EDOC, JAPIO, WPI

**Documents considered to be relevant:**

Category	Identity of document and relevant passage	Relevant to claims
A	GB 2165078 A (SHARP)	-
A	GB 2106299 A (SMITHS)	-
A,E	WO 97/27725 A1 (SEG)	-
A	WO 86/01364 A1 (BALL)	-
A	US 5517089 (RAVID)	-

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